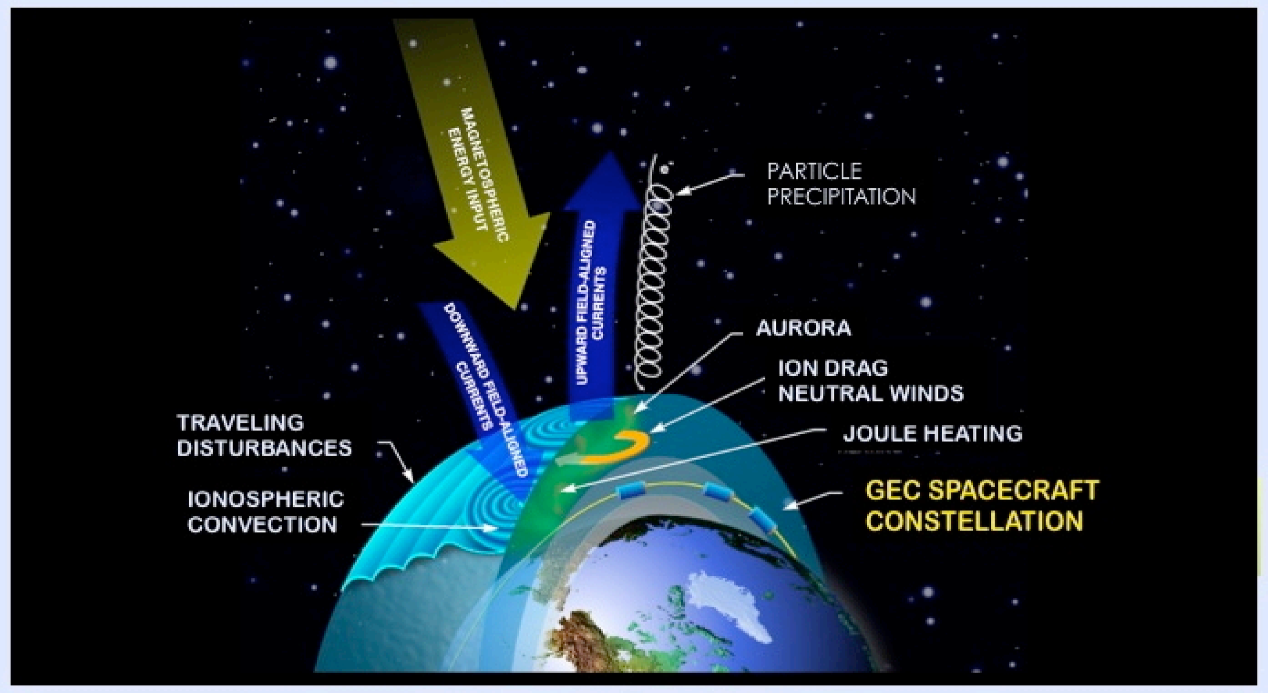
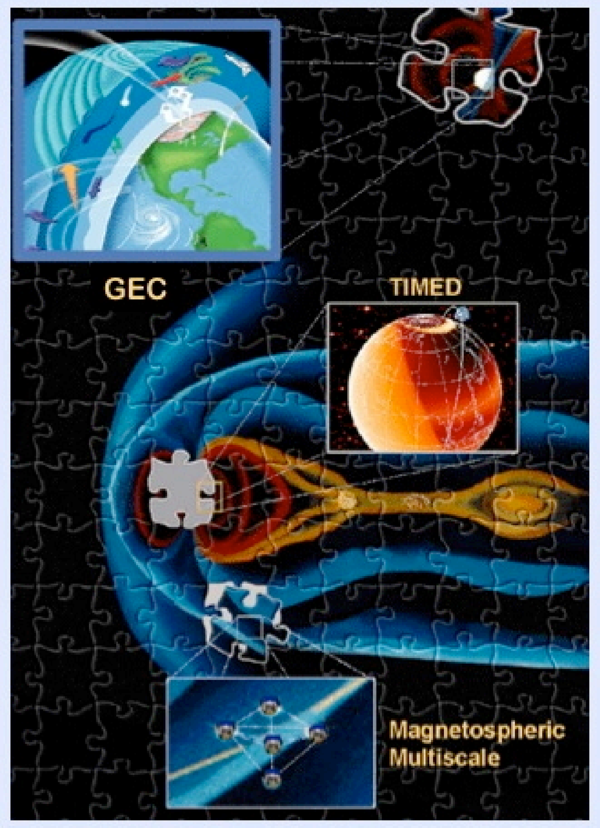
GEOSPACE ELECTRODYNAMIC CONNECTIONS (GEC)

A MISSION TO EXPLORE THE COUPLING BETWEEN THE LOWER BOUNDARY OF GEOSPACE AND THE MAGNETOSPHERE

GEC
A Mission to the Threshold of Space



Mission Context



- GEC will help to bring closure to our understanding of the inseparable role the thin electrically conducting region at the top of our atmosphere plays in the coupling of solar wind energy, through the magnetosphere down to the upper atmosphere.
- Multiple deep-dipping s/c are used, otherwise the broad range of coupled, spatial and temporal scale processes would not be resolvable.
- GEC's focus is on a much needed piece of the Geospace puzzle partially filled by RBSP, MMS, IMAGE, and TIMED missions.

Strategic Objectives

- Unravel the electrodynamic coupling processes in the Ionosphere Thermosphere Magnetosphere (ITM) system, including the resolution of the temporal and spatial scales of the energy transfer and resulting energy distribution in the IT regime.
- Determine the cross-scale coupling processes that control the interaction of the ionosphere–atmosphere system with the magnetosphere.

Science Priorities

Priority	Key Question
1. Ion-Neutral Collisional Interactions	*How do the collisionally coupled charged and neutral atmospheric constituents in the IT boundary layer respond to electrodynamic inputs imposed from space?*
2. Scales of Electrodynamic Drivers and Responses	*How are the spatial variations and persistence of the electrodynamic drivers related to the neutral responses?*
3. Evolution and Feedback	*How, and under what conditions, do the responses evolve and feed back on the drivers?*

Fundamental Science Context

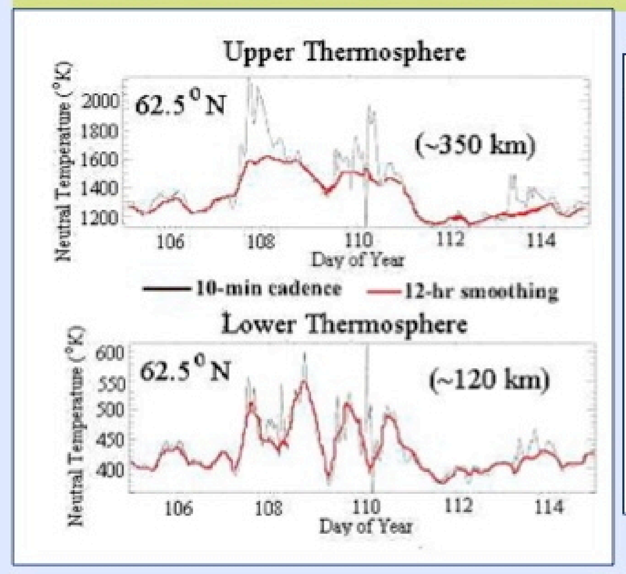
•We think we know all of the fundamental mechanisms, but we still don't understand how they combine on different scales.

•The Earth's ionosphere is well characterized, but we still lack measurements of the physics of the I-T system and its synergy with the magnetosphere.

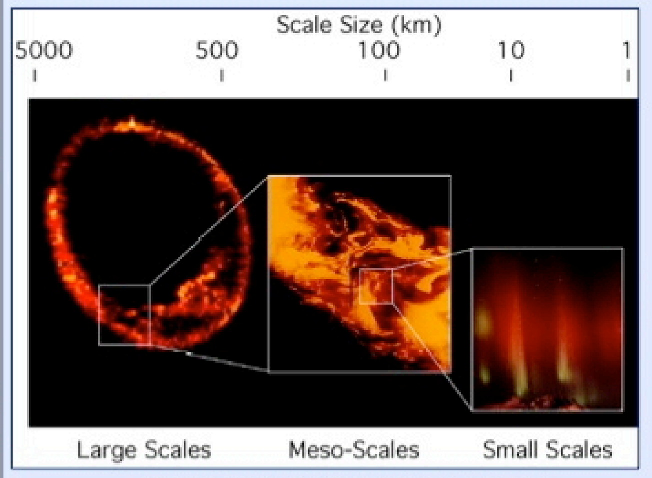
•This is basic MHD physics of the most complex kind, with a partially ionized plasma.

"Ion-neutral interactions are fundamental to our understanding both of geospace and of other planetary environments"

Why Multi-satellite Mission to Low Altitudes?
The ionosphere–thermosphere interface is highly dynamic and structured and dependent on altitude



Modeled temperatures for magnetic storm inputs averaged over two scale sizes. Responses depend on scales of inputs and altitude (from Crowley, 2003).

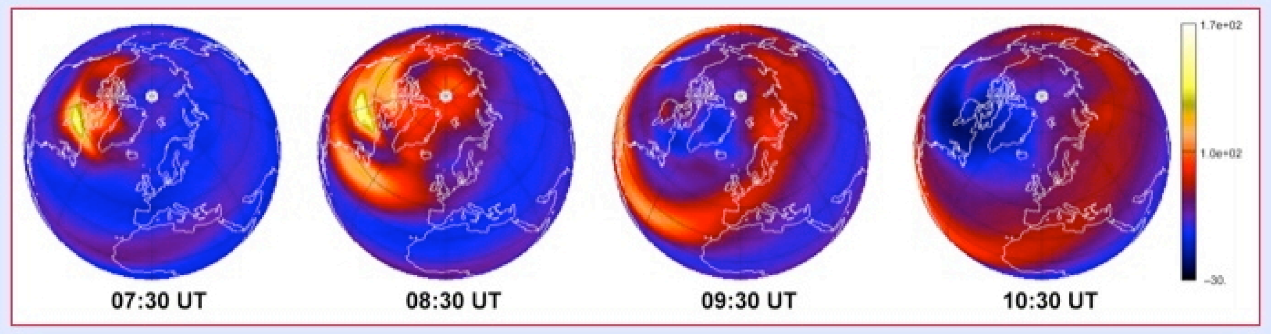


Broad range of auroral structures.

GEC's multipoint measurements at altitudes throughout the lower thermo-sphere will measure inputs and responses.

Globally Traveling Disturbances

GEC will be able to track the initiation of such disturbances in small-scale heating regions in the auroral zone and track their evolution over increasingly larger areas.

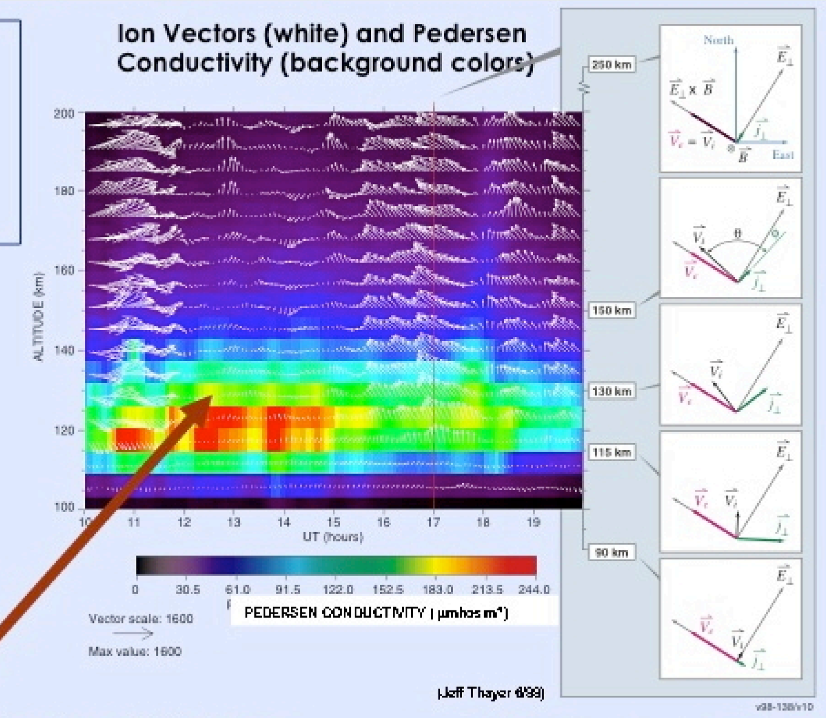


Changes in neutral density at 300 km altitude. NCAR TIEGCM simulation. Atmospheric response to a magnetic storm.
(Images courtesy of G. Lu/NCAR.)

Why Deep Dipping to 130 km?

Sondrestrom Incoherent Scatter Radar

- Ionosphere very conducting between 90 and 180 km
- Ion velocity vector departs by ~45° from the ExB direction around 130 km

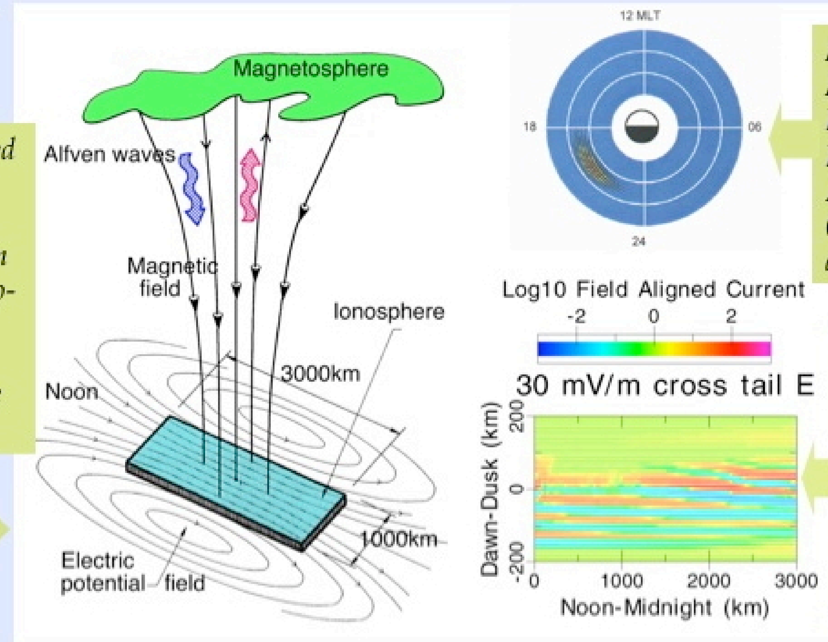


Current Closure Region Overlaps 130 km—GEC's Approximate Targeted Altitude

EXB, ion velocity, current at five altitudes, same time

Alfvén Waves

Precipitation-caused changes in conductivity propagate as Alfvén waves between iono-sphere and magnetosphere, producing multiple arcs



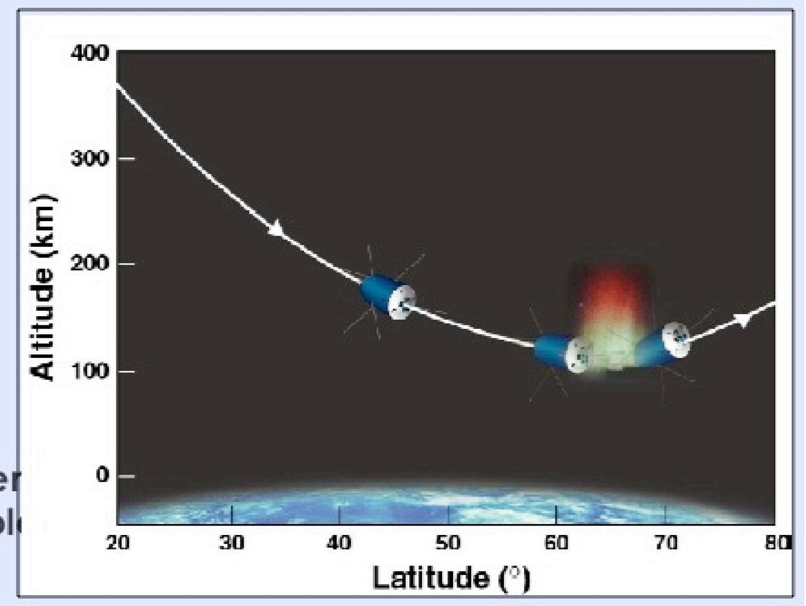
Modeled Multibanded, Drifting Discrete Auroral arcs (Pokhotelov et al.)

Simulated Sun-Aligned Arcs, regions of upward and down-ward currents (Sojka et al)

For understanding of Arc GEC will make sequential observations (10s -30min.) of E and B through same limited volume of space

Pearls-on-a-String Orbit Configuration

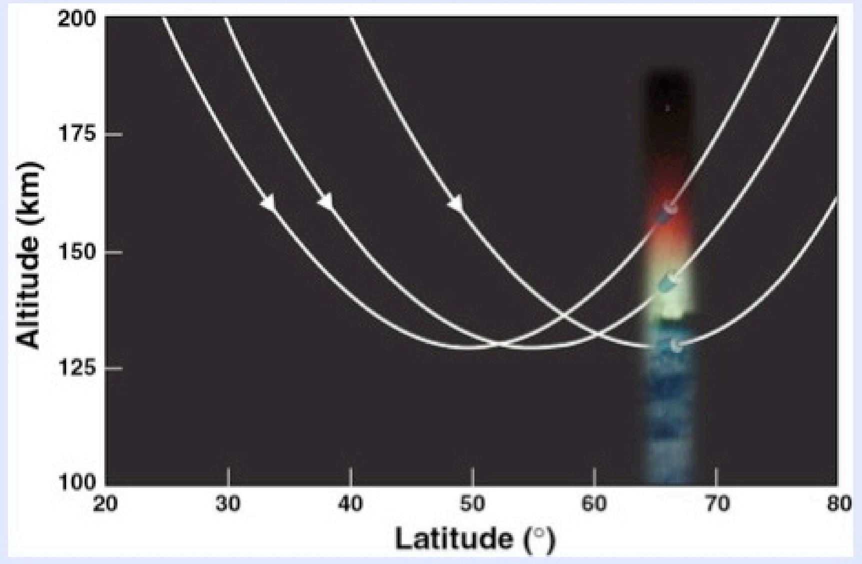
- Baseline GEC orbit: 83° inclination, 2000 x ~200 km.
- Near horizontal path for long distance near perigee—allows separation of time and horizontal structure.
- Different spacing between each spacecraft—multiple scale resolution.
- Goal: ten weeklong, deep-dipping campaigns for all spacecraft with perigees of ~130 km.



Plotted is 2000x130 km orbit, perigee at 65°.
Traversal time plotted ~14 minutes.

Petal Orbit Configuration

Changing argument of perigee for spacecraft and adjusting phase along orbit provides capability of measuring altitude profile.

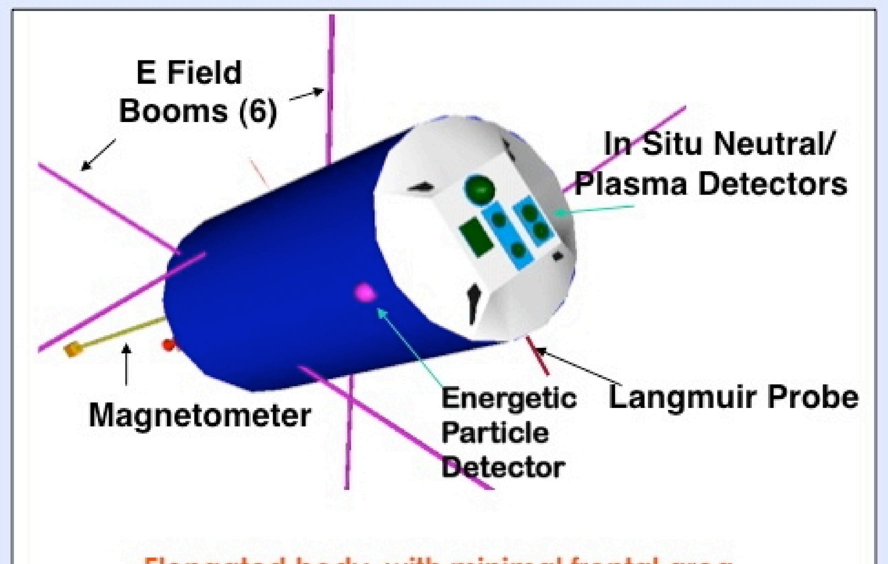


Plot is for 2000X130 km orbits with arguments of perigee at 65, 55 and 50 degrees.

Three-Spacecraft Design for Deep-Dipping and Minimization of E&M Disturbances

Concept Spacecraft:

- Max. Mass: ~1,000 kg (Delta II Capability)
- Fuel needed for more than a half-dozen weeklong dips to 130 km: ~few hundred kg
- Instruments: ~80 kg (All TRL 8-9)
- Size for cylinder: ~1m diameter, >5m long
- E-Field booms: ~10m



Elongated body, with minimal frontal area
Body-mounted solar arrays

Well Formulated Mission Concept

•Science well defined in two NASA Science Definition reports (*http://stp.gsfc.nasa.gov/missions/gec/gec.html).*

•Mission concepts were offered by three NASA funded industry studies:
A 3-s/c deep-dipping mission, with a Delta-II launch, was estimated to fit within the Explorer class budget cap.
No large technology hurdles.